Air Refreshment by Passive Systems for Energy Efficient Buildings

***RafriBAT** Project 2012-2015*

Project Leader: Professor Brahim BENHAMOU

Responsible of the Renewable Energies & Energy Efficiency Laboratoy, CNEREE

Cadi Ayyad University, Marrakech

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المركز الوطني للدراسات و الأبحاث حول الماء والطاقة

National Center for Research and Studies on Water and Energy (CNEREE)

Cadi Ayyad University, Marrakech

CNEREE, UCA Marrakech
2 labs, EnR2E, WSE

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- ✓ R&D in Energy and Water,

- ✓ Third part Studies in Energy and Water (expertise for private and publics companies),

Outline

- Context
- Project Objectives
- Working Methodology
- Working Group
- Running studies
- First results

RafriBAT Project

- Context
- Objectifs du Projet RafriBAT
- Méthodologie de travail
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- Livrables, Actions menées ([illegible]-Avr. 2012) & Études en cours
- Premiers résultats

World Context …

Construction is one of the most important economic sectors worldwide. The **total world's annual output of construction** is close to **3 trillion** $US and constitutes almost **one-tenth of the global economy** *[Conf. Int. Contractors Asso., http://www.uneptie.org/outreach/wssd/docs/sectors/final/construction.pdf].*

About 30% of the business is in Europe, 22% in the United States, 21% in Japan, **23%** in **developing countries** and 4% in the rest of the developed countries.

Buildings use almost 40% of the world's energy, while it is responsible for almost 70% of emitted Sulphur oxides and 50% of the CO^2 *[United Nations Council for Human Settlements , 1993]*

World Context …

Energy consumption of the building sector is high. Although figures differ from country to country, **buildings are responsible for about 30-40% of the total energy demand**

[Matheos Santamouris, PASSIVE COOLING OF BUILDINGS, Advances of Solar Energy ,2005].

Application of intensive energy conservation measures has stabilized energy consumption for heating in developed countries. However, **energy needs for cooling increases in a dramatic way**. The increase of family income around the world has made the use of air conditioning systems highly popular.

World Context …

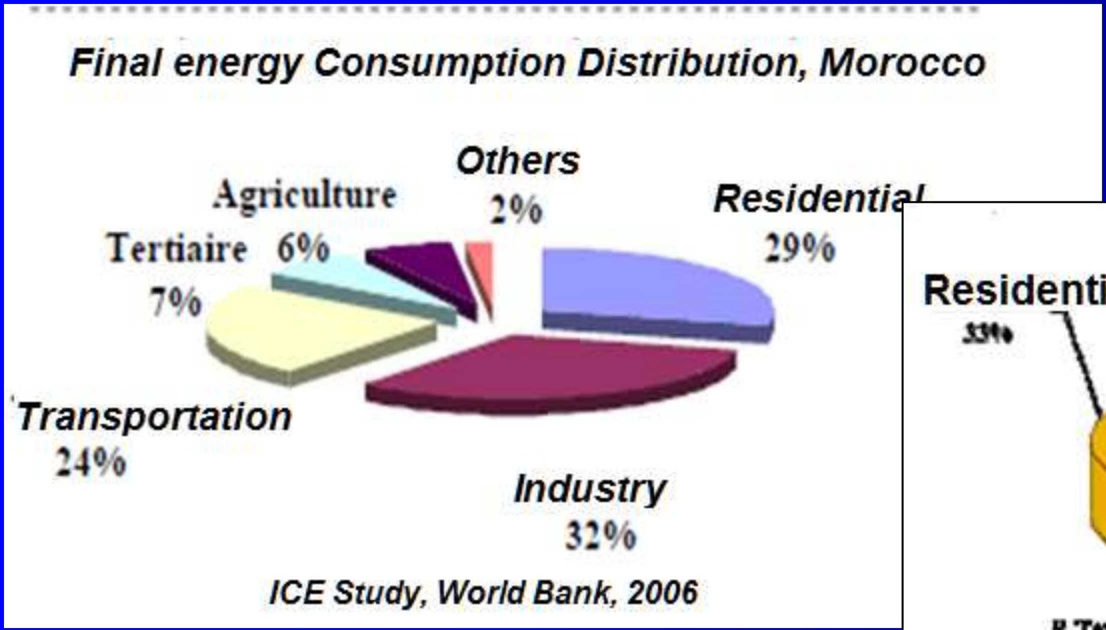
The **impact of air conditioner** usage on **electricity demand** is an **important problem** as **peak electricity load increases continuously**, forcing utilities to build additional plants. In parallel, serious environmental problems are associated with the use of air conditioning.

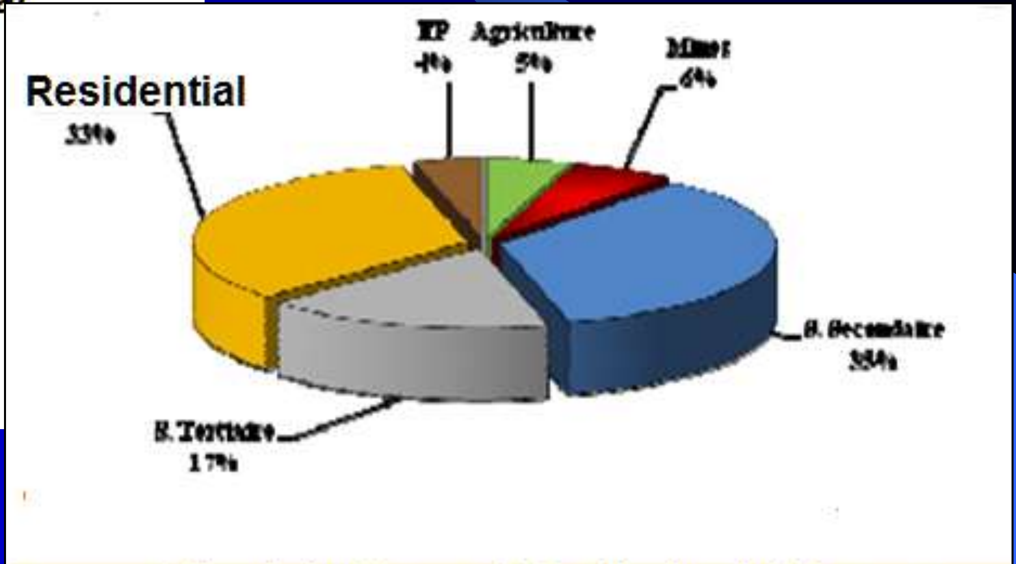
Actually there are more than 240 million air conditioning units and 110 heat pumps installed worldwide according to the International Institute of Refrigeration *[2002].*

[Matheos Santamouris, PASSIVE COOLING OF BUILDINGS, Advances of Solar Energy ,2005].

…Context In Morocco…

➢ **Energy consumption in buildings** sector represents **29%** of the total national energy consumption *[World Bank, ICE, 2006]*





Electricity Demand Distribution in Morocco [ONE, 2010]

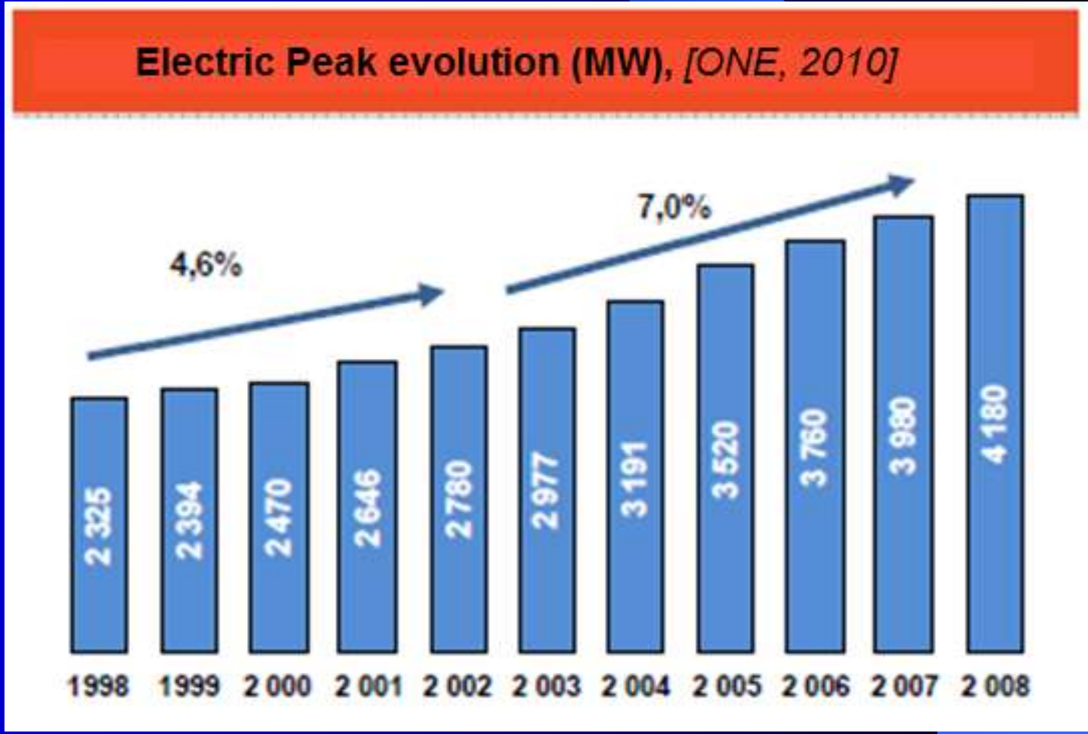
➢ Electricity is the dominant energy in air conditioning systems and thus contributes largely to the energy **consumption in building sector** which represents **33%** of the total demand *[ONE, 2010]*

…Context In Morocco

The Peak Electricity Load exhibits an increase of **7%** during the last decad. This increase is essentially due to the large augmentation of the building consumption. Indeed:

The Peak Electricity occurs:

- Daily at **7:00PM-9:00PM.**
- Yearly in **July-August** .



Evolution of the Peak Electricity Load (MW) *[ONE, 2010]*

Energy Efficiency in Buildings

In Morocco, the building sector, presents a great potentiel for Energy Efficiency, which can be achieved by the integration of natural, passive or semi-passive techniques for air refreshement and heating.

Remember that traditional buildings (*Medinas*) procur an acceptable thermal comfort, as they are integrated in their climate

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Research Project **RafriBat** (2012-2015)

Solar Passive Systems for Air Refreshment in buildings

Partners:

- CA University Marrakech *: FS Semlalia, CNEREE, FST Gueliz,*
- H2AC University Casa: *FS Ain Chock,*
- Architects *: Elie Mouyal, Boukartacha,*
- Private Companies*: GMTA, Istichar Engineering Office*
- ADEREE *: ongoing ?*

Budget: **3'000'000 MAD** (4 years)

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Research Project **RafriBAT** (2012-2015)

Objectives

- **Monitoring** and **Dynamic Modelling** of the energy consumption of some test-buildings in Marrakech, integrating passive and hybride systems cosnsidered in this study *(AMYS house & MOUYAL architect cabinet, ...).*

- Construction of "**test-cells**" for the experimental assessment of thermal performances of some passive and hybrid systems for air cooling and heating, in order to demonstrate the Energy Efficiency of these techniques, in Marrakech climate.

PASSIVE TECHNIQUES FOR AIR REFRESHMENT

3 types

1. **Solar and Heat Protection Techniques**: building form and orientation, solar protections, thermal insulation,
2. **Heat Modulation Techniques:** This modulation involves the thermal capacity storage of the building structure (thermal inertia). These techniques reduce the Peak Electriciy Demand and provide modulation of internal temperature with heat discharge at a later time. These techniques are efficient for large outdoor temperature swings. The cycle of heat storage and discharge must be combined with means of heat dissipation, like night ventilation, so that the discharge phase does not lead to overheating.
3. **Heat Dissipation Techniques:** These techniques deal with the potential for disposal of excess heat of the building to an environmental sink of lower temperature. Dissipation of the excess heat depends on two main conditions:
   i/ The availability of an appropriate environmental heat sink;
   ii/ The establishment of an appropriate thermal coupling between the building and the sink as well as sufficient temperature differences for the transfer of heat.

The main processes of heat dissipation techniques are: **ground cooling (**sink = **soil**), **radiative cooling (**sink = **sky**), **convective** and **evaporative cooling (**sink = **air**),

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Considered Techniques & systems

- Wall & Roof Thermal Insulation.
- Cool Roof.
- Thermal inertia of the building.
- Solar Cheminey solaire / traditionnal coupole.
- Earth-to-Air Heat Exchanger (*EAHX*).
- Day-Night Dephaser.
- Evaporative Cooling.

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Research Project **RafriBAT** (2012-2015)

Methodology

- **STEP 1: Monitoring of the existant buildings** in Marrakech which integrate some passive systems. This monitoring will give us experimental data for modelling validation (STEP 2) as well as precise and real informations about the output of these systems on thermal comfort in the hot and dry Marrakech climate.

- **STEP 2: Dynamic Modelling of the existant buildings**: This modelling will provide us with an accurate powerfull tool for buildings simulation. This tool will be used in STEP 3.

- **STEP 3: Construction of Test-Cells** in order to exprimentally evaluate the thermal performances of the considered cooling/heating passive systems

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Research Project **RafriBAT** (2012-2015)

Involved Research Laboratories :

- **Energy Processes Team** / LMFE, FS Semlalia, University Cadi Ayyad , Marrakech

- **EnR2E Labortory,** CNERE, National Centre for Research & Studies on Water and Energy, University Cadi Ayyad, Marrakech

- **Materials, Metrology and Process Laboratory for Energy and Environment**, FSTG, University Cadi Ayyad Marrakech

- **Thermal Sc. Group,** Laboratory of Physics of Materials, Micro-electronic, Automatic et Thermal Sciences, FS, University Hassan II-Ain-Chock Casablanca.

10 Seniors Researchers :

FS Semlalia, UCA, Marrakech :

Professor Brahim Benhamou, Professor Amin Bennouna,
Professor Abderrahim Brakez, Professor Hassan Hamdi

Laboratoy EnR2E, CNEREE, UCA, Marrakech :

Dr Lahcen Boukhatem, Dr Fatima Aitnouh,
Dr Abderrahmane Hajjaj

FST Gueliz, Marrakech:

Professor Hassan Chehouani

FSAC, Casablanca :

Professor Mustapha EL Alami Professor Mustapha Najam

Professionnal Partners :

Elie MOUYAL, Architect DPLG , Marrakech.
Rachid BOUQERTACHA, Architect DPLG, Marrakech.
Engineering Office ISTICHAR, Marrakech
Private Company GMTA, Marrakech
ADEREE, *ONGOING. ?*

International Collaborators :

Dr Pierre Hollmuller, 'Environment Sciences Institute, University of Geneva, Suitzrland.
Prof. **Daniel Rousse**, ETS, Montréal, Technologies of Energy Chair, Canada.
Prof. **Horst ALTGELD**, IZES, Saarbruecken, Germany

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Académie Hassan II des Sciences et Techniques

Projet de recherche **RafriBat** (2012-2015)

Running Studies (2012)

Masters:

- Characterization of construction materials *(Student:* Mustapha Boumhaout)
- Modelling of Soil-Building Heat Transfers *(Student: Abdelkader Haki)*
- Dynamic Modelling of a Sheltred Building in Marrakech*(Student: Ouedraougo)*
- '*Outdoor Test-Cells*' State of the art, *(Student: Mohamed Mouhou)*
- Dynamic Modelling of a typical house in Marrakech *(Student: Mouna Benadada)*

PhD (Doctorates):

- Dynamic Modelling and Monitoring of a EAHX connected to a Passive House -AMYS- in Marrakech *(Student : Hassan Bouhess)*

  → POSTER AMT2012
- Dynamic Modelling and Monitoring of a Passive House -AMYS- in Marrakech *(Student : Mustapha Kajja)*
- Thermal Characterization of local construction materials *(Student : Qasmi)*

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First resultats 2011-2012

Modelling and Monitoring of a villa type passive house –AMYS- in Marrakech

This study is financialy supported by
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*Programme PARS, **RafriBAT** Project 2012-2015*

Description of the AMYS house

Villa type house in the Marrakech suburb.

The Building is oriented South *(with a deviation of 17° to East.)*

2 floors, **1st floor**: 116.7m² & **2d floor**: 136.5m²
Volume = 1000m^3

PASSIVE SYSTEMS:

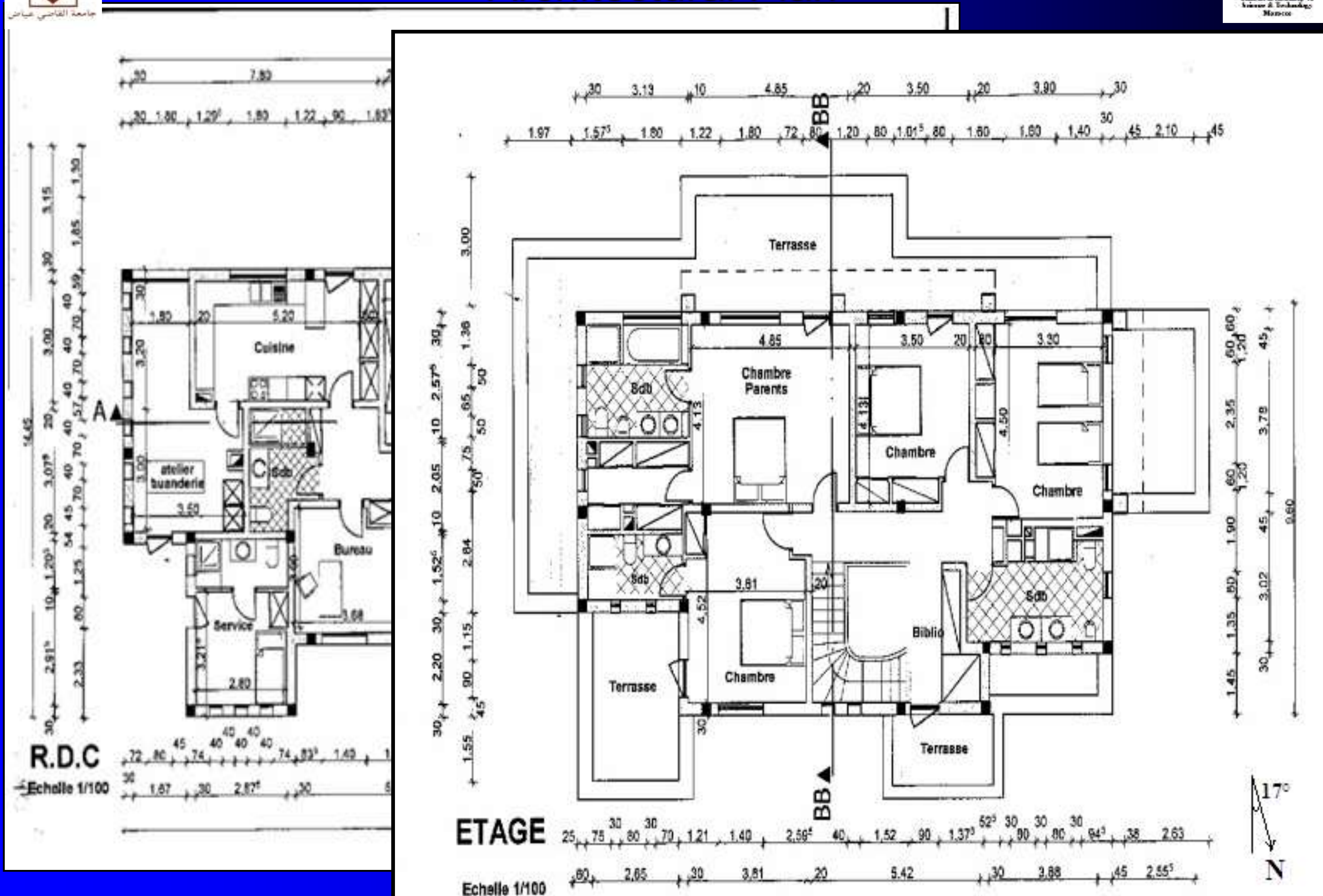
- External walls are thermally insulated (10 cm of glass wool)
- The roof is thermally insulated (6cm of extruded polyurethane)
- Overhang along the South facade in the 2d floor (width= 1.20m)

- EAHX: - 3 pipes of 70m length & 16cm ID
  - Burried at 2m at the entrance & max: 3m
  - ACH: 0.5Vol/h (167 m^3/h/pipe)
  - 3 Exits in the 1st floor (Grand Salon, Petit Salon & Office)
  - 1 Exit in the 2d floor (stairwell)

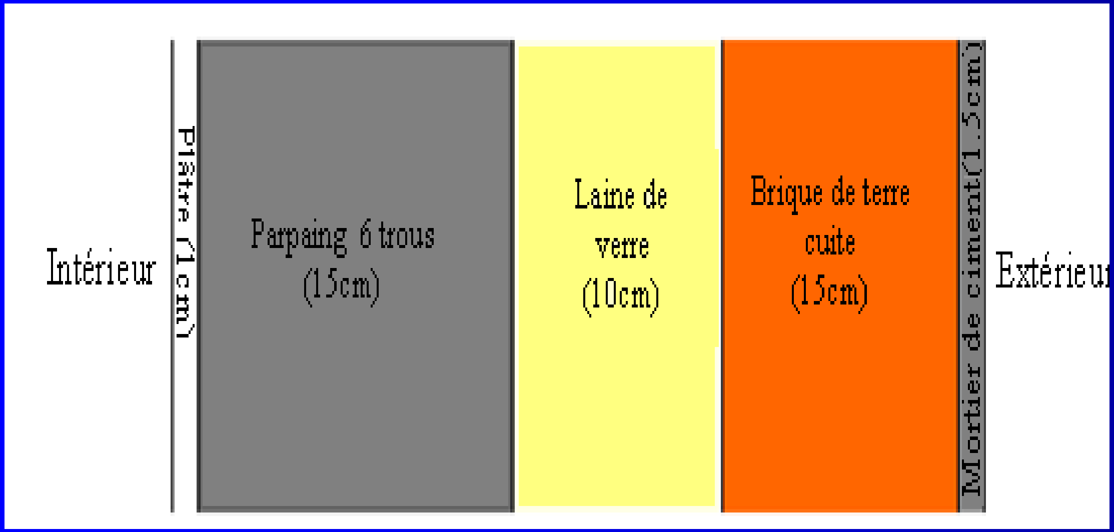

North view

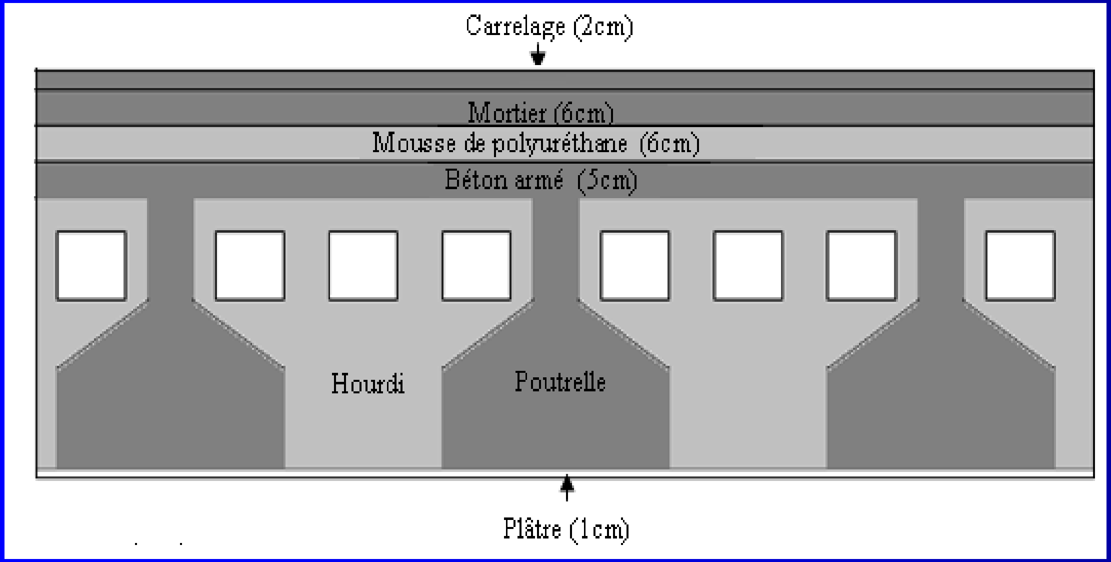

North-West
View

Architectural Plan



Details of the passive systems





Modelling

Thermal behaviour of the house is simulated using **hourly transient multizones** sofware (TRNSYS) along a given year.

In this preliminary study, the is subdivised in 2 zones; **ZONE 1= 1st floor**; **ZONE= 2nd froor**.

The simulation consist on calculating the mean **temperature into each zone**. The heating and cooling loads are thus deduced on the basis of set points: **20°C for heating and 25°C for cooling**.

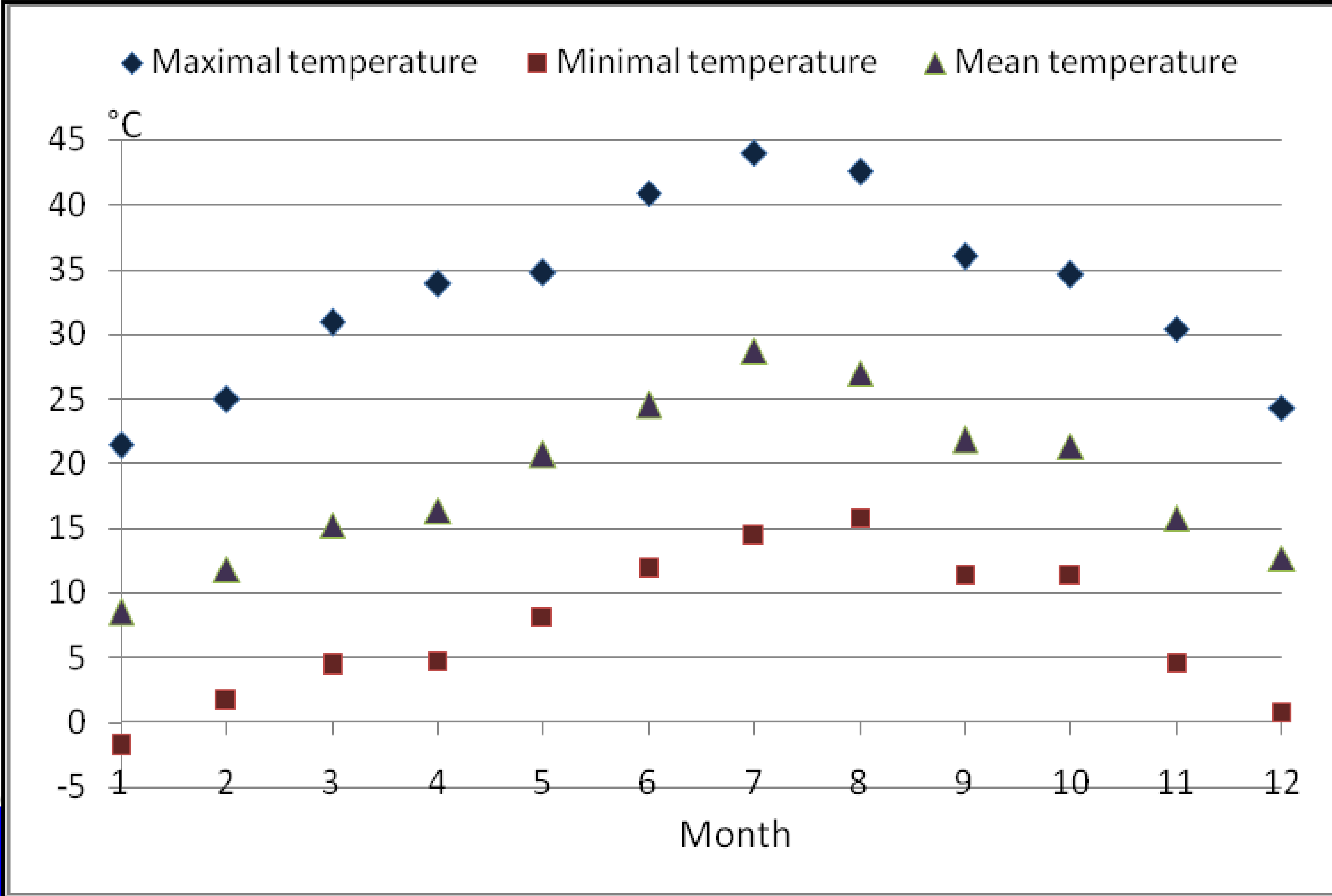
Hypothesis :

1. Each zone is considered as **unique space**.
2. **Glazed area** are sinple glazed **without stores**.
3. **The door and windows frames** are not considered.
4. **ALL the doors and windows are closed** around the simulation period.
5. Internatl heat generation is ZERO (**unoccupied house**).

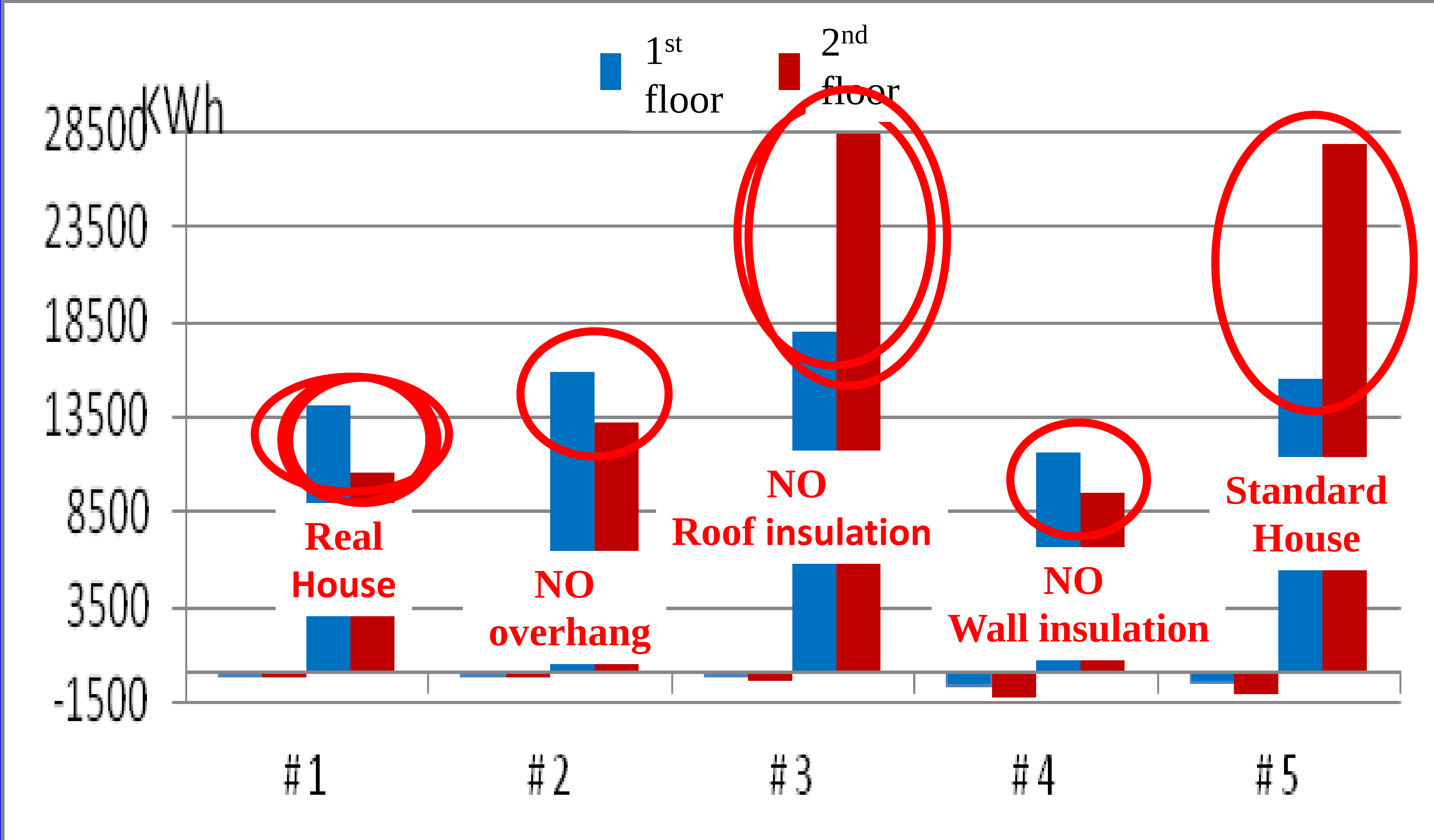
Studied Configurations

Passive System	***Overhang***	***Roof***	***External walls***
#1 (real house)	Yes	Insulated	Insulated
#2	**NO**	Insulated	Insulated
#3	Yes	**No insulation**	Insulated
#4	Yes	Insulated	**No insulation**
#5 (standard house)	**NO**	**No insulation**	**No insulation**

Marrakech weather 2009

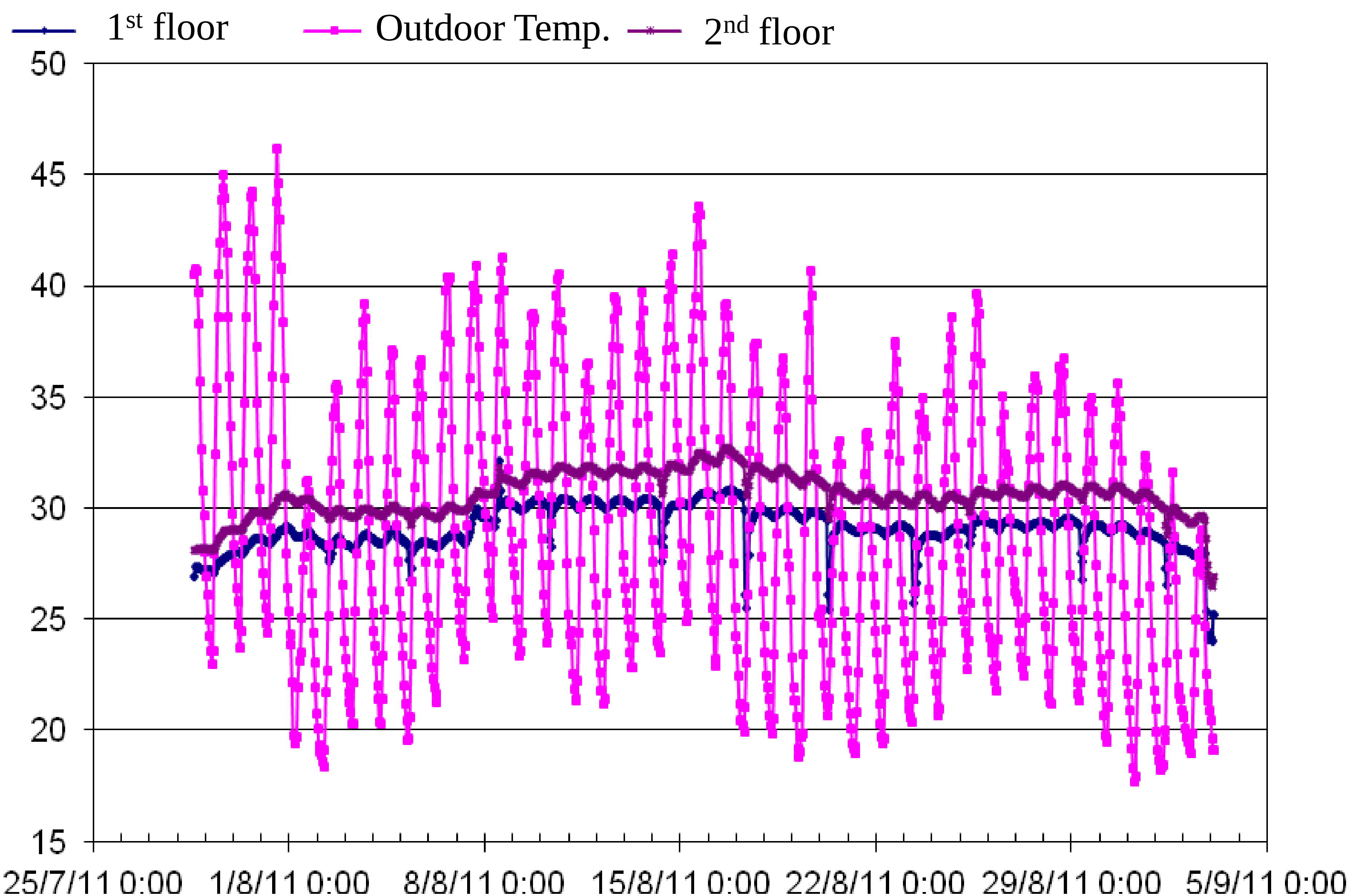


Results….



Total cooling and heating loads of the AMYS house for 2009

38 days Monitoring, First results (28 July - 3 Sep. 2011)



Conclusions

- The roof insulation and the overhang reduce the thermal load either for heating and cooling while Wall insulation reduces the heating load and increases the cooling one.

- This premlinary study shows that the most recommanded technique, In Marrakech, is the roof insulation. This technique reduces the overall thermal load by 43%.

- The first results of the monitoring of the building show that internal temperature varies between:
  - **26 et 31°C** in the 1st floor.
  - **28 et 32.7°C** in the 2nd floor,

  For outdoor temperatures osillating between **18°C and 46°C** over about 6 weeks (25-jul au 5-sep-2011)

  (the house was unocuppied during the monitoring period)

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Thanks,

Questions …?